Echo Balloon Satellites

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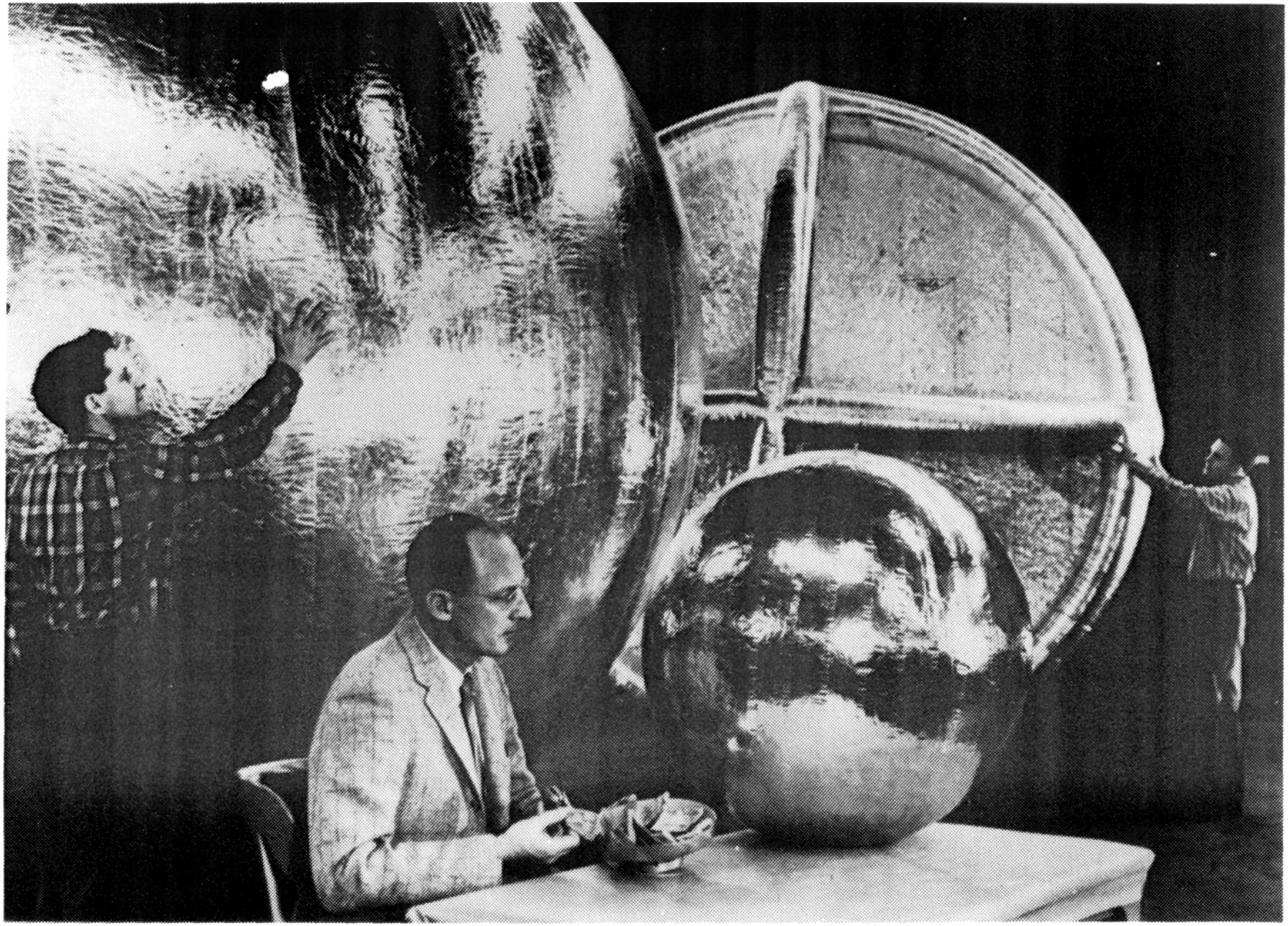
A Short History of Echo I

- Echo I launched on August 12, 1960
  - 100’ diameter balloon, made of 0.0005” aluminized Mylar®
  - World’s first communication satellite
  - Initially proposed by William J. O’Sullivan, Jr. of the NACA at Langley, as a way to measure atmospheric density (January 27, 1956)
  - Achieving success required perseverance in the face of launch and balloon inflation failures
- Very Visible U.S. entry in the “Space Race”
  - The Russians always seemed to be ahead but couldn’t match the brightness of Echo I



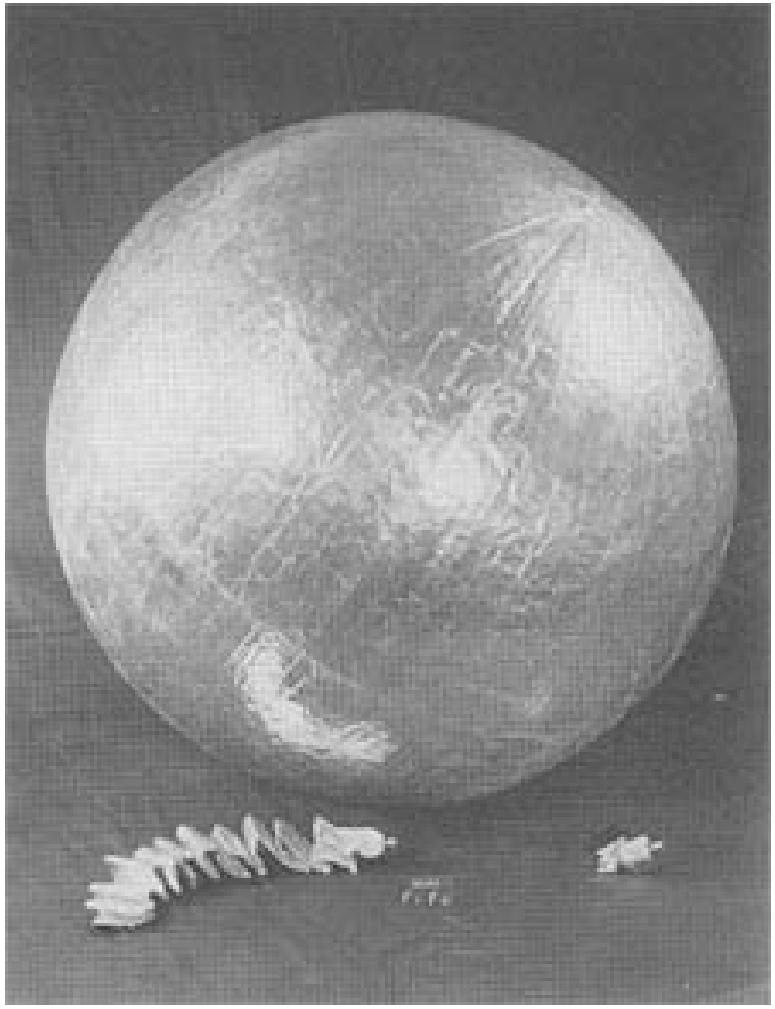
William O'Sullivan examining balloon satellite prototypes.

Developing the Balloon Material

- Langley's Space Vehicle Group tested dozens of plastic and metal foils (even gold)
  - Had to withstand the extreme range of temperatures from 300°F in direct sunlight to -80°F when in the shadow of the earth
- Settled on a new plastic material called "Mylar" made by E. I. du Pont de Nemours & Co.
  - Was being used for recording tape and for frozen-food bags that could be put directly into hot water
  - Manufactured in very thin sheets only half as thick as the cellophane wrapper on a pack of cigarettes
- More difficult to find was an effective metal covering for the plastic that would make it visible to radars,
  - The O'Sullivan group "tested metal after metal, looking for ways to paint them on Mylar in layers far thinner than airmail onionskin paper."
- Adopted a new technique for vaporizing aluminum on plastic being developed by the Reynolds Metals Company
- The fabrication problem was solved by cutting the material into gores and gluing them together along overlapping seams
  - They built 20-inch domes for inflation tests.

Many Small Balloons Built, Tested and One Launched

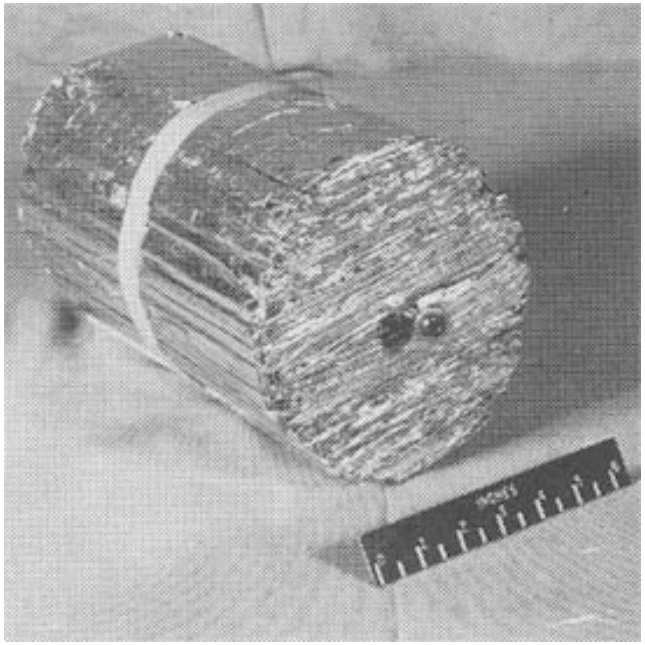
To determine the capacity of the 30-inch "Sub-Satellite" (right) to withstand the high temperature of direct sunlight in space, Langley researchers subjected it to a 450°F heat test. Results indicated that the aluminum-covered Mylar plastic would effectively reflect the dangerous heat.

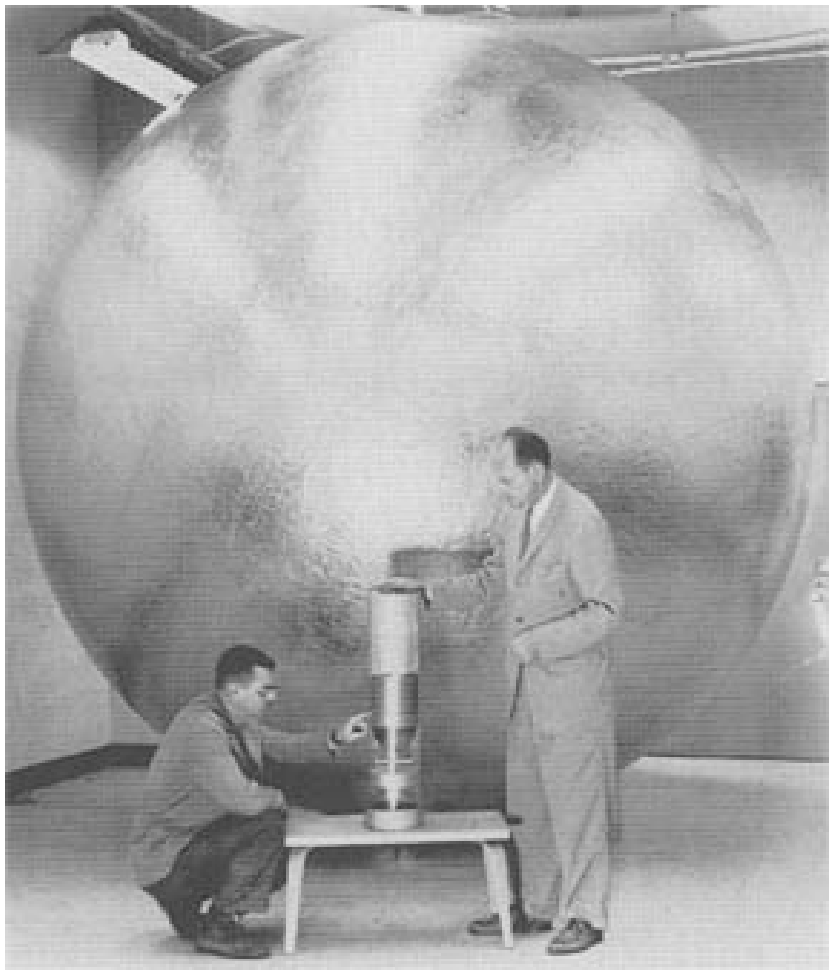


A 30” sphere was launched on Vanguard SLV-5 on April 13, 1959, but the 2nd stage failed

A 12’ Balloon Was Launched Twice and Failed To Orbit Twice

In July 1959, William J. O'Sullivan (right, standing) and an unidentified engineer examine the capsule containing the tightly folded and packed 12-foot-diameter Beacon satellite (below).

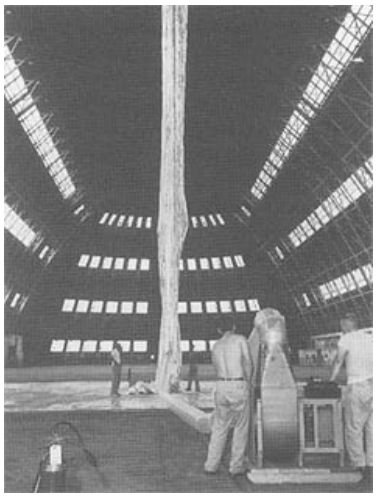


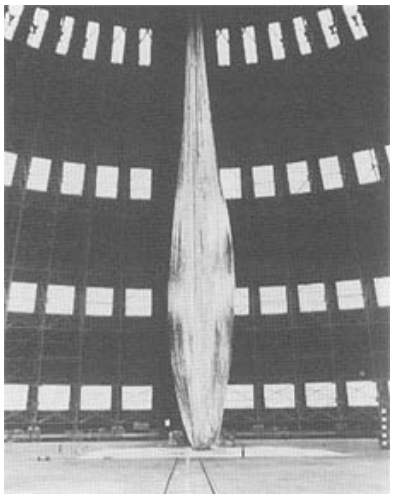


Start of 100’ Echo Balloon

- On 18 April 1958, Langley submitted to NACA headquarters a proposed research authorization entitled, "A Large Inflatable Object for Use as an Earth Satellite"
- Hugh Dryden, testified before the House Select Committee on Science and Astronautics on April 22nd
  - Dryden explained how a large aluminized balloons (100’ diameter was proposed) could be inflated in orbit and used for communication tests.
- Accompanying Dryden, O'Sullivan inflated a full-size (12’) Beacon satellite "to demonstrate the structural, optical, and electronic principles involved."
  - O'Sullivan testified that a 10 stories high balloon "would reflect radio signals around the curvature of the earth using frequencies not otherwise usable for long range transmission, thus mostly increasing the range of frequencies for worldwide radio communications and, eventually, for television, thus creating vast new fields into which the communications and electronics industries could expand to the economic and sociological benefit of mankind."
- The NACA formally approved the proposal on 8 May, but work on the big sphere had actually started at Langley on a high-priority basis

Ground Testing of Echo I



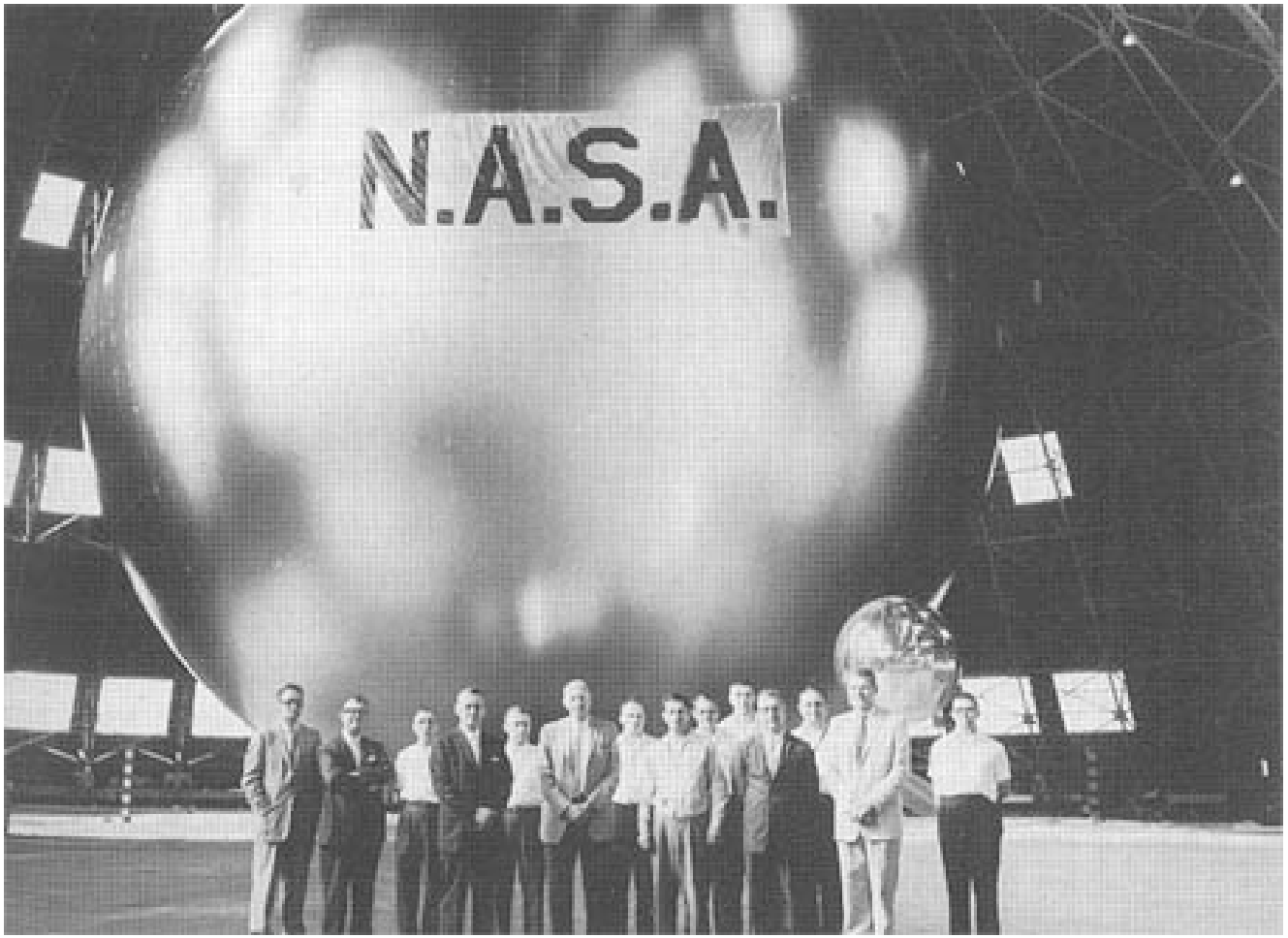


Testing Echo 1's inflation (above) in the navy hangar at Weeksville, NC took half the day but proved worth the trouble.

Langley engineers Edwin Kilgore (center), Norman Crabill (right), and an unidentified man take a peek inside

Balloon made by General Mills

Successful Ground Inflation



The Echo 1 team stand in front of their balloon
Balloon made by G. T. Schjeldahl Company of rural Northfield, Minnesota

Suborbital Test Flight of 100’ Balloon on 10/28/1959

- A booster called "Shotput," an experimental two-stage Sergeant X248 rocket, performed flawlessly. The rocket took the 26-inch-diameter, spherical, 190-pound payload canister-inside of which the uninflated 130-pound aluminum-coated Mylar-plastic satellite had been neatly folded-to second stage burnout at about 60 miles above the ocean. There, the payload separated successfully from the booster, the canister opened, and the balloon started to inflate.
- Then, unexpectedly, the inflating balloon exploded. The payload engineers had left residual air inside the folds of the balloon by design as an inflation agent. The air expanded so rapidly, because of the zero pressure outside, that it ruptured the balloon's thin metallized plastic skin, ripping the balloon to shreds. Shotput I was history; the use of residual air to help blow up the balloon had been, in Crabill's words, a "bad mistake.“
- Initially publicized as a success – later embarrassed to admit “it was not supposed to work that way”
- **4 more Shotput launches before a successful inflation**

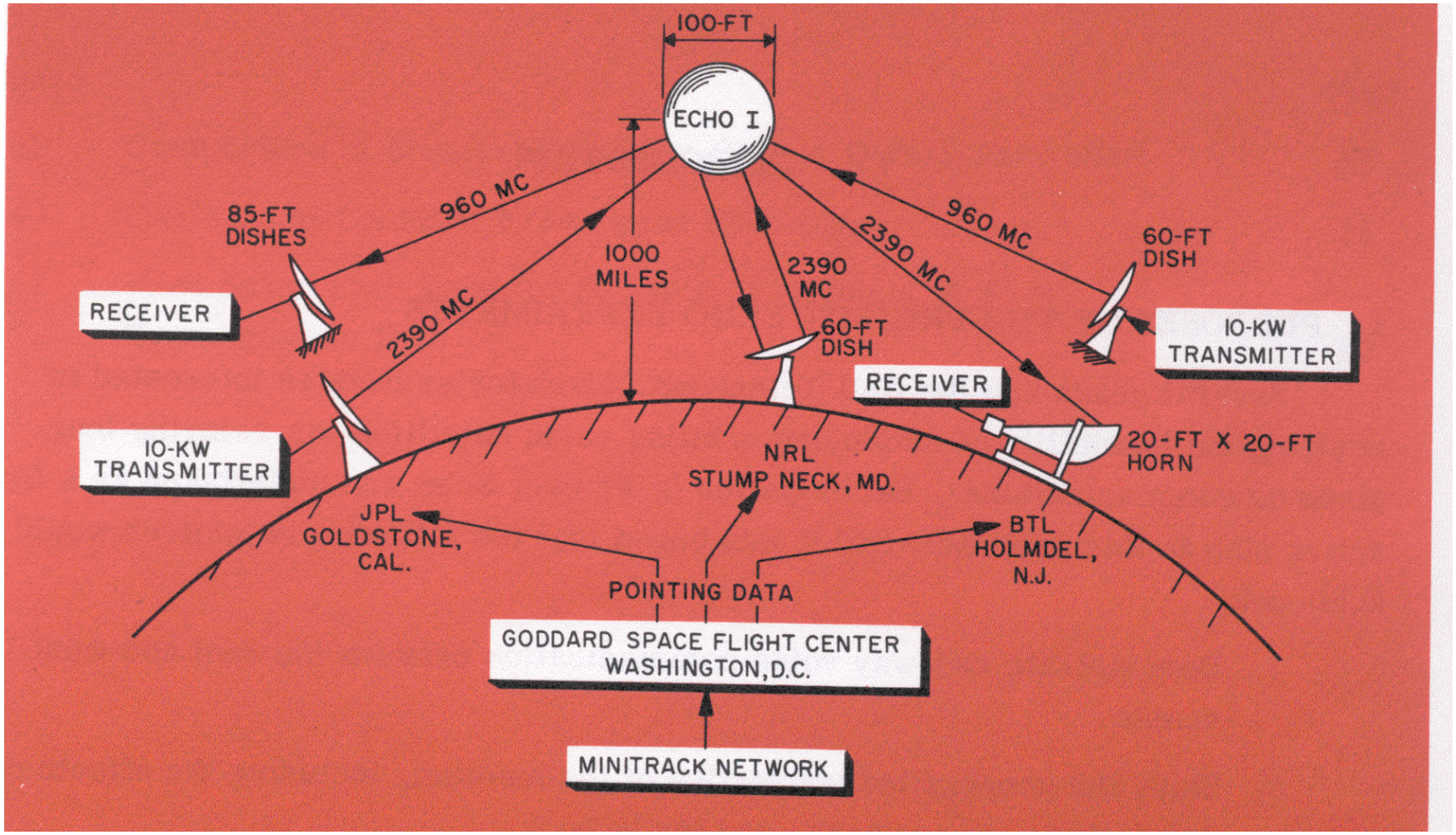
Echo I Launched August 12, 1960

- First try on May13th failed to get to orbit on the first Thor-Delta
- Three months !!! later, successful orbit on Thor-Delta-2
- The big and brilliant sphere had a 31,416-square foot surface of 0.0005” Mylar plastic covered smoothly with a mere 4 pounds of vapor-deposited aluminum. All told, counting 30 pounds of inflating chemicals and two 11-ounce, 3/8-inch-thick radio tracking beacons (packed with 70 solar cells and 5 storage batteries), the sphere weighed only 132 pounds
- Initial orbit 820 X 911 nmi, 48.6-deg inclination
  - Reentered May 25, 1968

World's First Communication Satellite

- On Echo I's first orbit demonstrated coast-to-coast two-way communication using a satellite
  - Two 85' antennae at Goldstone, CA
    - Genesis of JPL's Deep Space Network
  - Bell Lab's low noise horn in New Jersey
  - Signals were within 1 db of expected
- Sent two-way message to France
- Later used to send messages from England to Russia

Echo I Communication Experiment



Echo I Was Not a Perfect Sphere

- Brightening and dimming occurred at RF and optical wavelengths

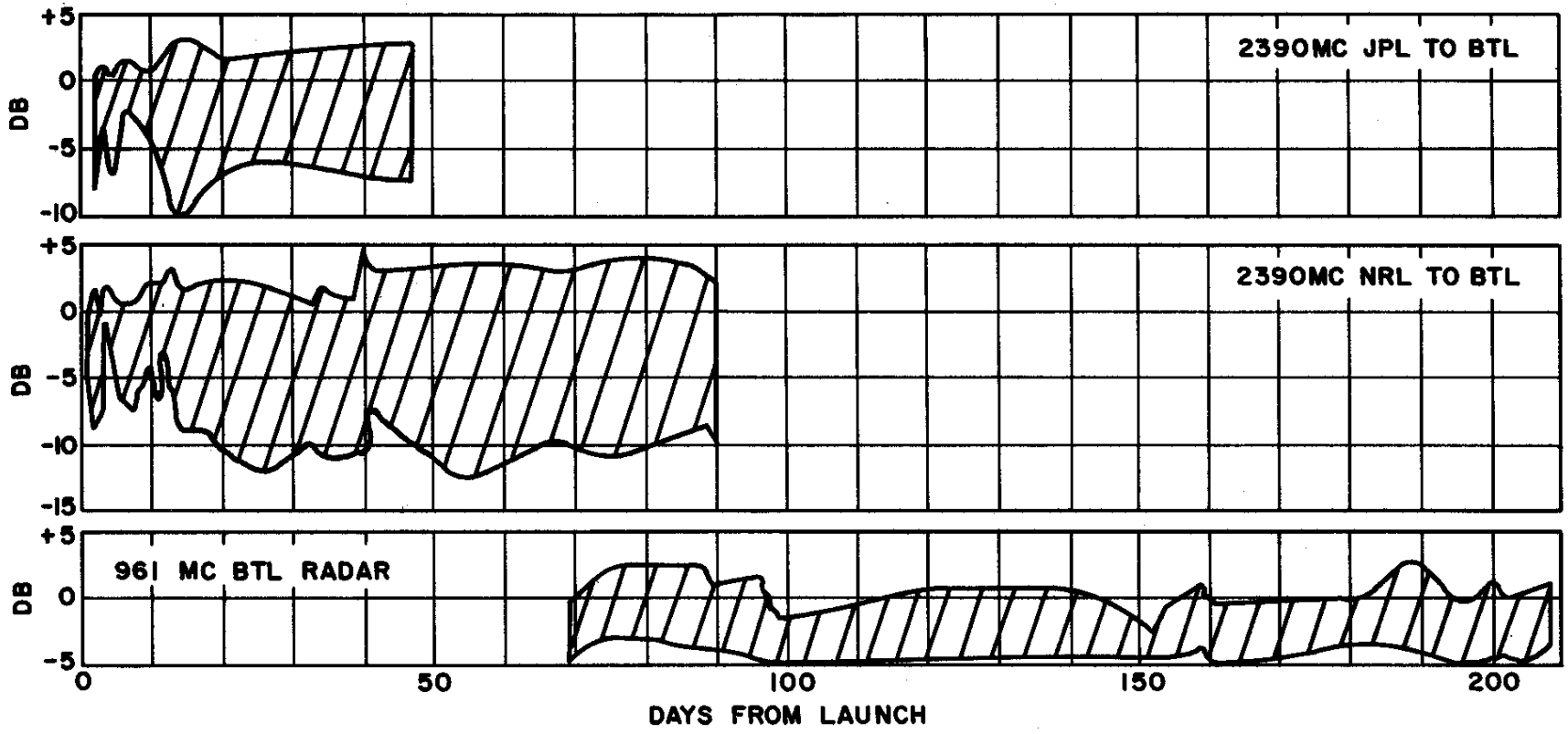
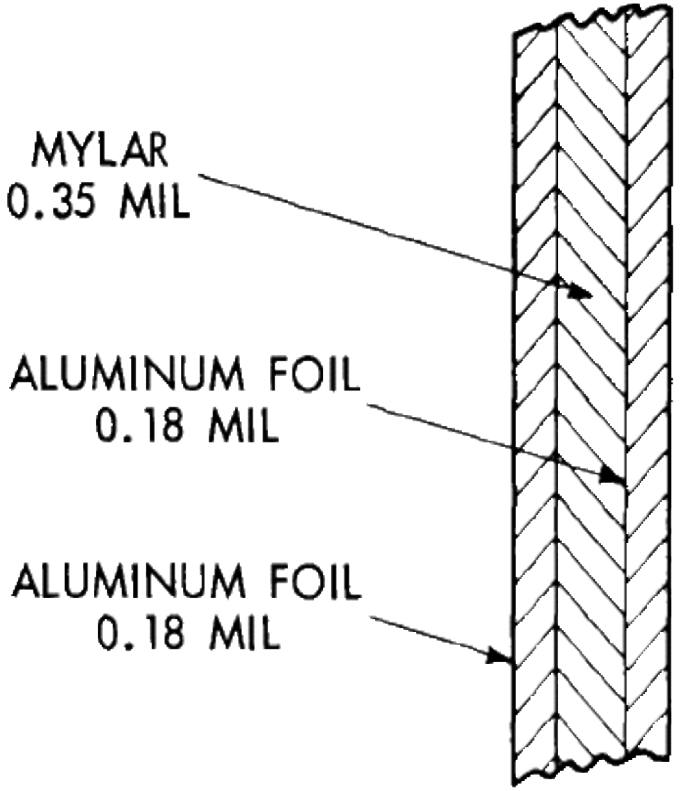


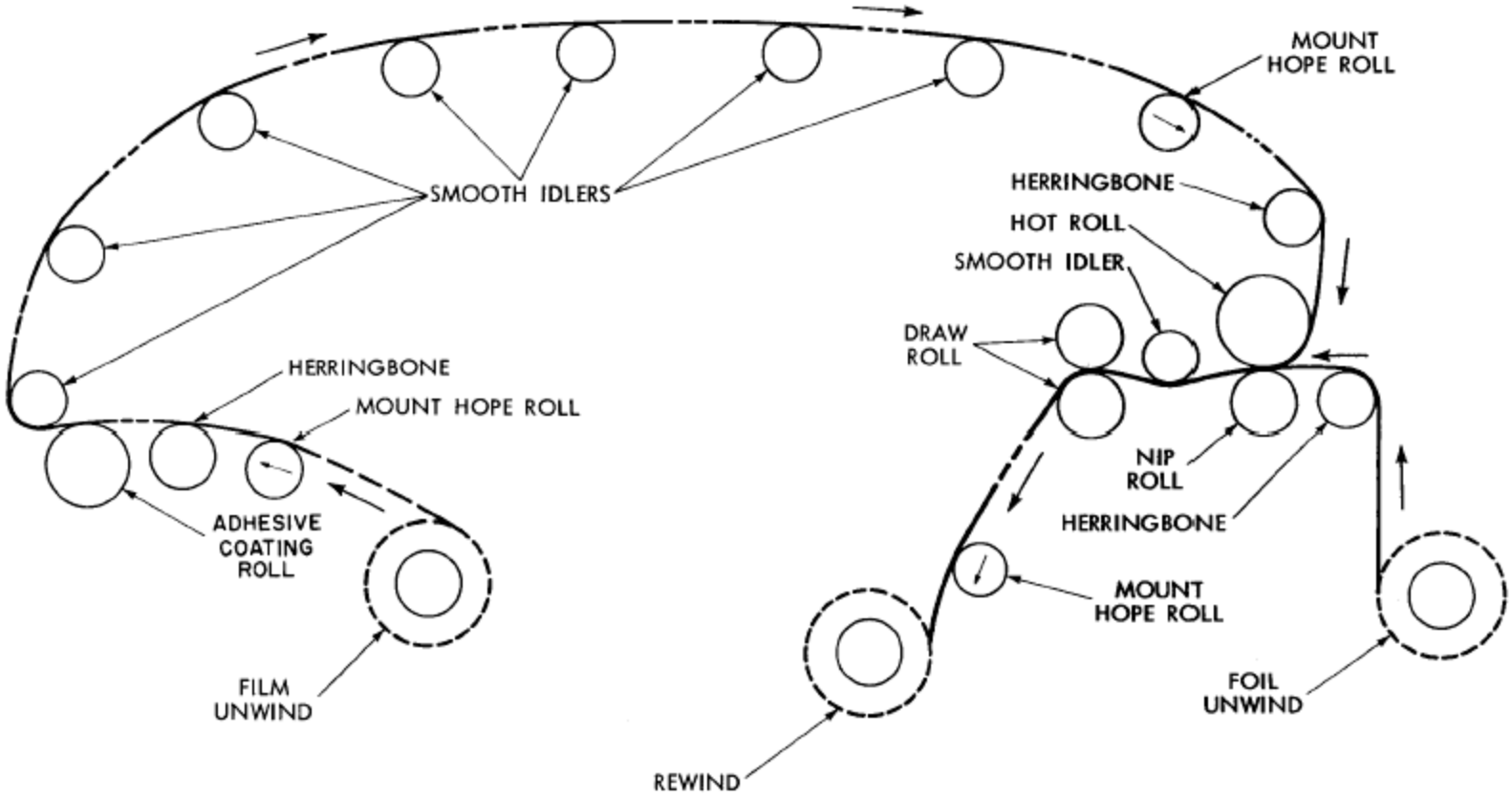
Figure 37. Variation of Peak-to-Peak Signal Levels With Time

A Short History of ECHO II

- Echo II launched on January 25, 1964
- Initial orbit 557 X 710 nmi, 85.5-deg
  - Reentered June 7, 1969
- Aluminum foil intentionally stressed above its yield point
  - Removed wrinkles
  - Able to hold spherical shape if pressure lost
- Coatings used were:
  - Outside - Alodine coated
  - Inside - black ink coated



Schematic of Laminator



Picture of Laminator

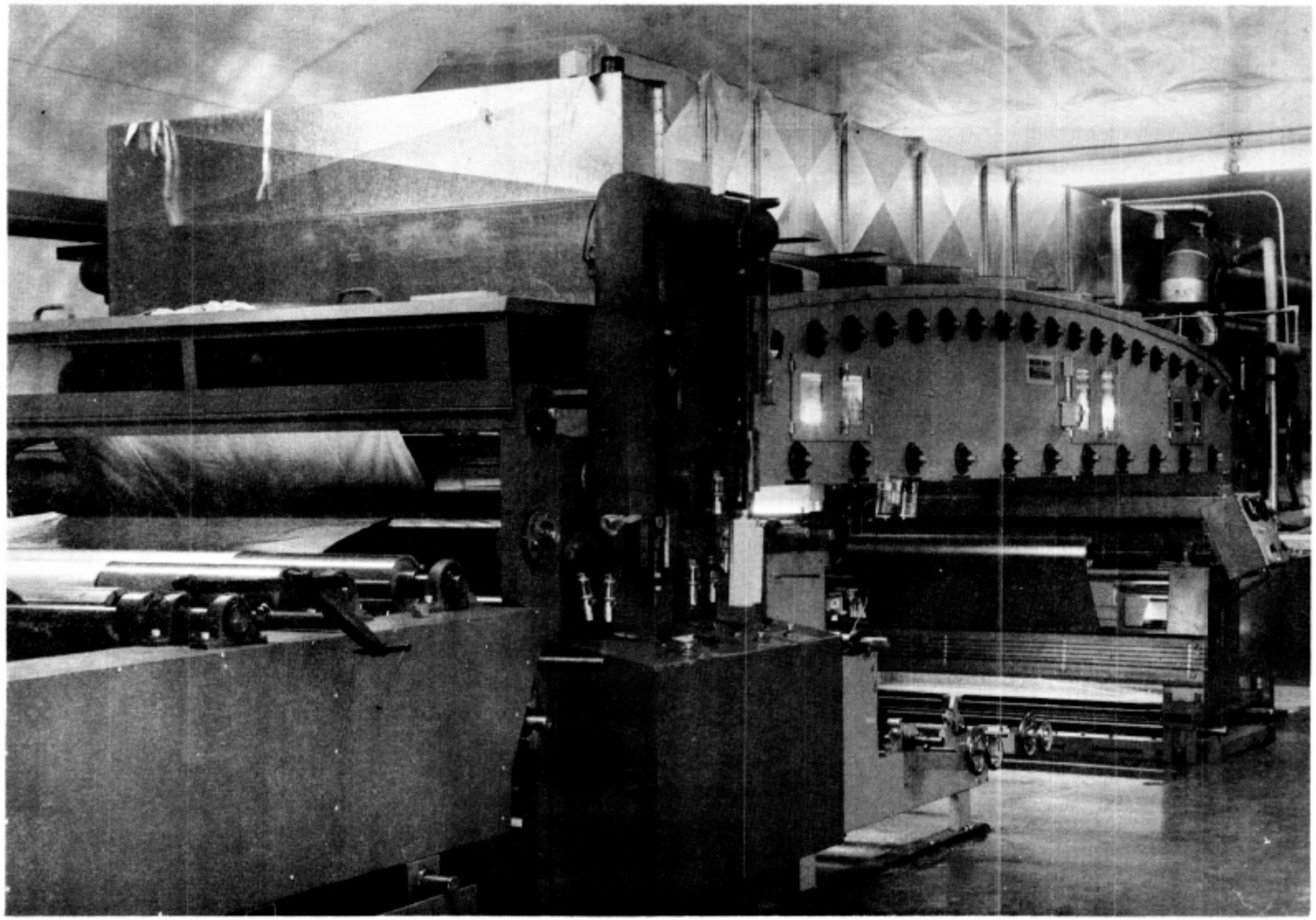


Figure 3-5. Eighty-Four-Inch Laminator (G. T. Schjeldahl Co.)

Echo II Construction Details

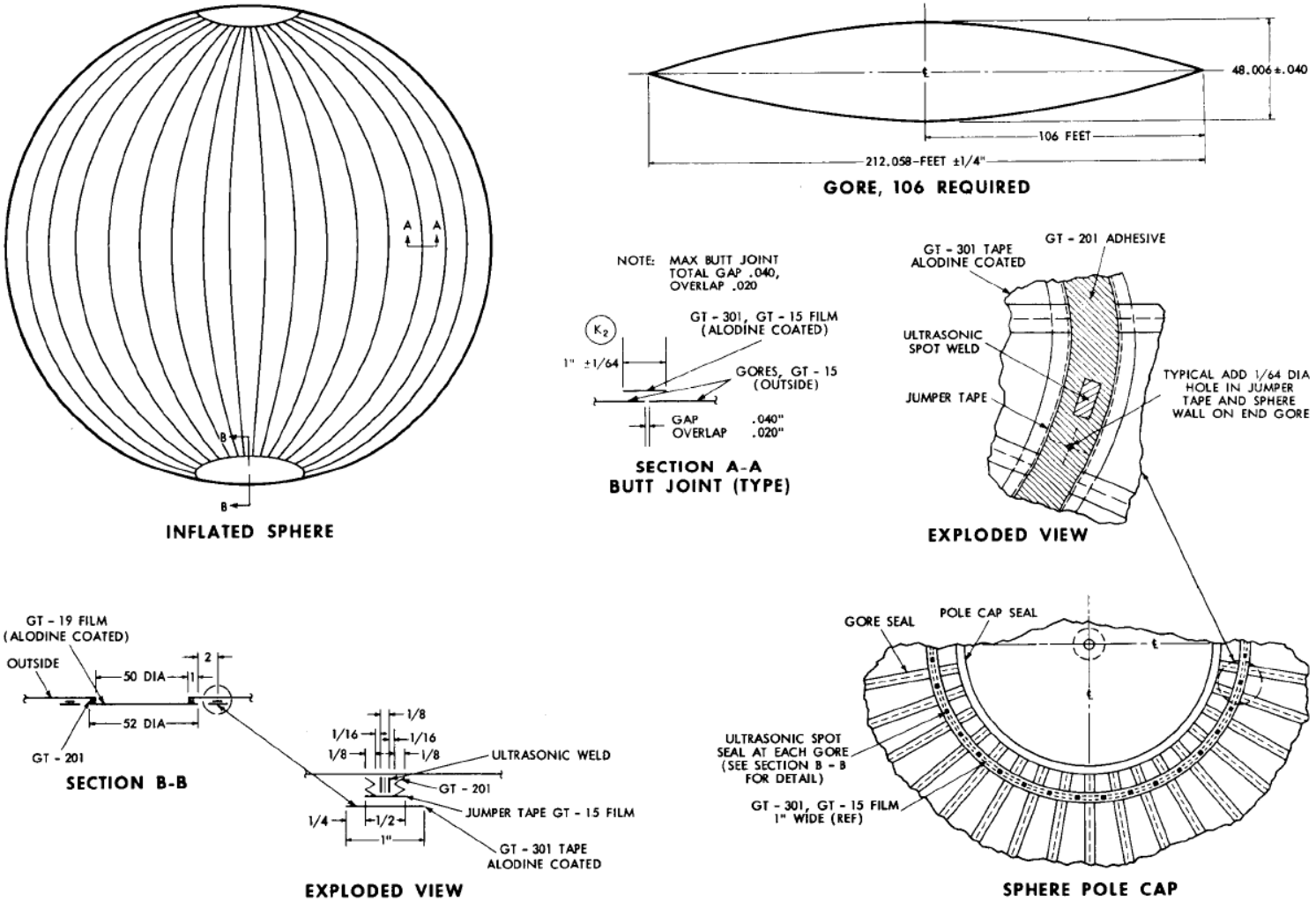
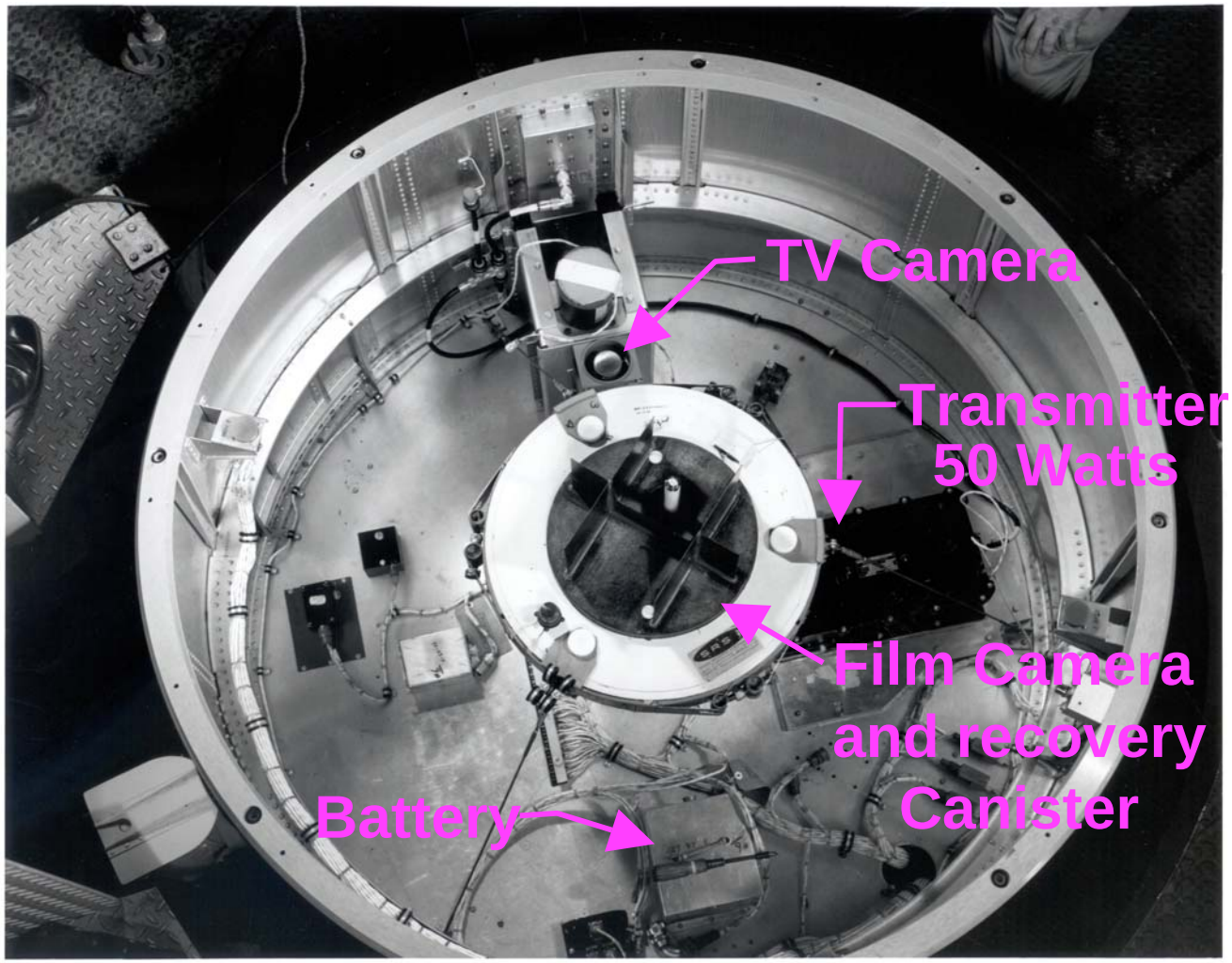


Figure 3-37. Electrical Continuity Jumper Strip and Pole Cap Installation

Two Sub-Orbital Inflation Tests

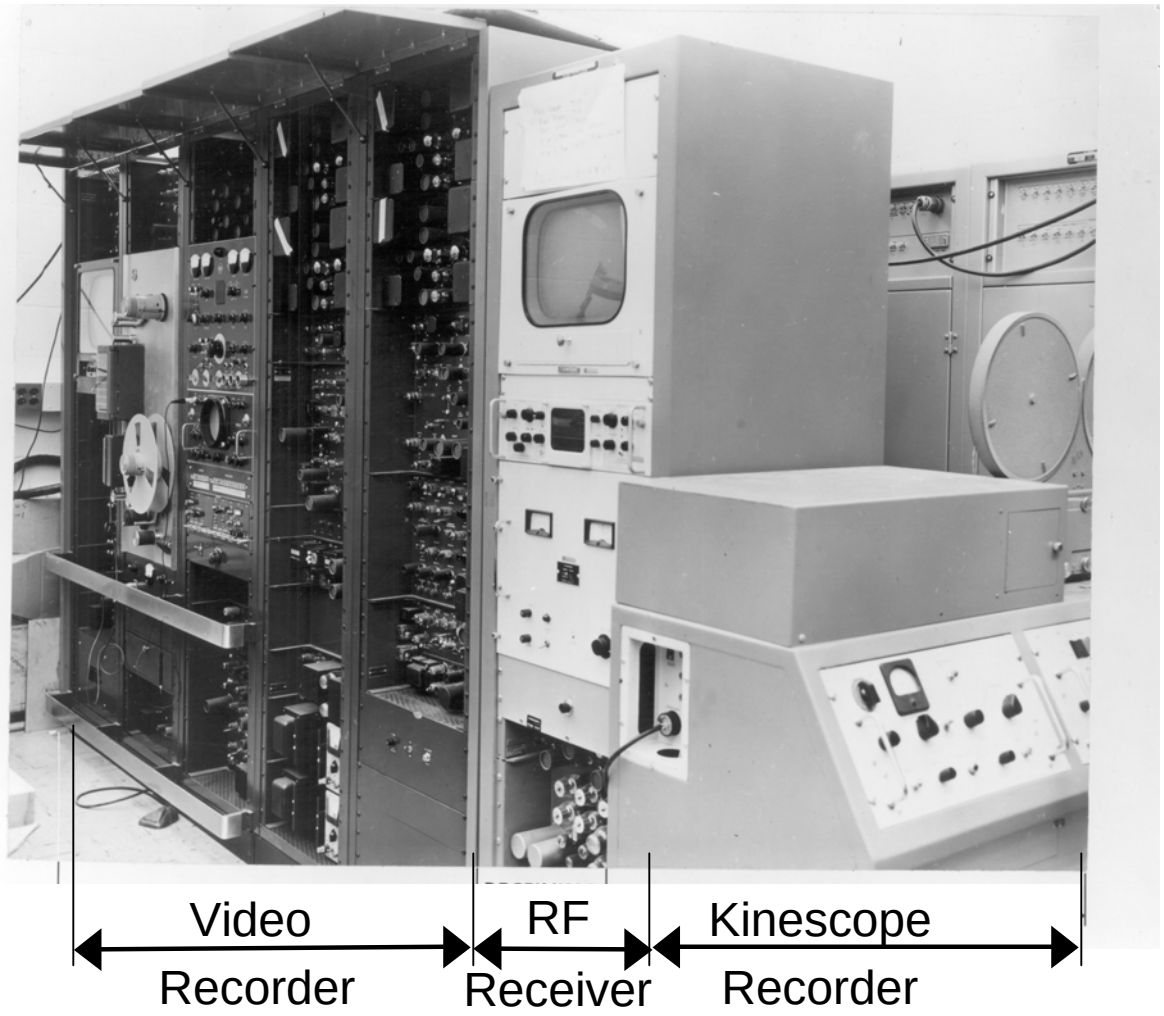
- 1st sub-orbital test launched 1/15/1962
  - The balloon split upon inflation
  - Too much residual air in balloon canister
  - First television from space
- 2nd sub-orbital test launched 7/13/1962
  - Balloon inflated OK, but pressure too low to achieve desired wrinkle-free surface
- Both tests were captured by a film camera and a TV camera mounted on launching rocket behind the balloon capsule
  - Film capsule recovered from ocean
  - TV broadcast to the ground giving a real-time view of the inflation

Film Canister and TV System



Ground TV Recording System

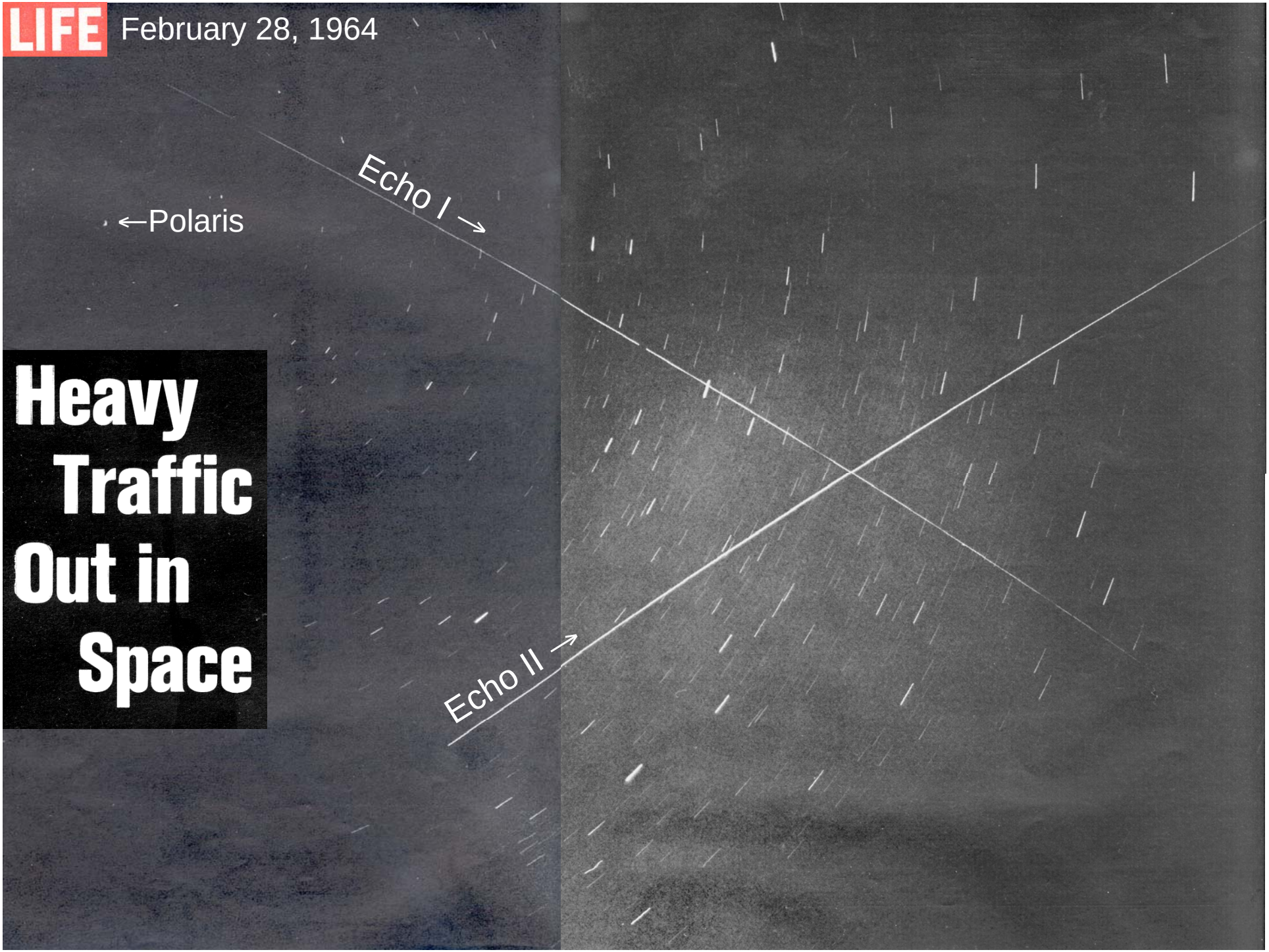
- Video was recorded on RCA studio recorders
  - 2” wide tape
  - 14” reels



Echo II Video System

- Used the same flight video system
- Ground equipment mounted in semitrailer
  - 2 RCA recorders, 2 receivers
  - Flight video and RF simulator
- Shipped to Durban, SA and trucked to Johannesburg, SA ground station
  - Initially did not work with their antenna
- Received ~15 minutes of video
  - Balloon inflated OK
  - Saw clouds towards end of pass
  - First video from orbit

LIFE February 28, 1964



Heavy Traffic Out in Space